

Why Study Mercury Reactions in Power Plant Plumes?

Coal-fired power plants have been identified as the anthropogenic source category that produces the largest air emissions of mercury in the U.S. – approximately 48 tons per year. Unlike other pollutants associated with power plant emissions (e.g., PM_{2.5} and ozone), concentrations of mercury in ambient air are generally far too low to constitute a health or environmental hazard. However, because mercury tends to convert to toxic methylmercury in terrestrial and aquatic environments after it leaves the atmosphere, and can bioaccumulate in food chains, humans can be exposed, via food consumption, to potentially harmful doses of Hg.

Depending on the coal type and combustion process, mercury can be released into the atmosphere from coal power plants in one of three basic forms: (1) gaseous elemental mercury (Hg⁰), which is relatively unreactive and can persist in the atmosphere for periods of months to years; (2) gaseous oxidized mercury (Hg²⁺), which reacts and returns to the earth's surface relatively quickly via wet or dry deposition; and (3) particulate-bound mercury, which is already in a relatively stable chemical form upon release. Virtually all of the particulate-bound mercury is removed at the plant via high-efficiency particulate collection devices; therefore, the type and location of environmental impacts associated with mercury releases from coal plants will be determined partly by relative proportions of Hg⁰ to Hg²⁺ in the stack exhaust. Atmospheric reactions that cause the mercury speciation profile to change after it is released, and other atmospheric processes governing cloud formation, precipitation, and particle deposition can also play an important role in the environmental impacts associated with mercury.

Questions regarding mercury speciation in power plant plumes could have important implications for U. S. policy regarding the control of mercury emissions from the electric utility industry. From a control technology standpoint, Hg²⁺ is easier to remove from power plant flue gases than Hg⁰; however, nationwide mercury trading programs for power plants will be much more viable if power plant mercury releases are primarily in the elemental form, or if atmospheric processes cause mercury to convert from Hg²⁺ to Hg⁰ shortly after release. Conversely, if the mercury released from the stack is in the oxidized form or converts to the oxidized form within the power plant plume, nationwide trading would be less desirable because of the potential for local “hot spots” of mercury deposition and subsequent bioaccumulation immediately downwind of each plant.

A complete understanding of the transport, transformation and environmental fate of mercury released into the atmosphere is needed to allow accurate modeling of the mercury cycling process. However, even the best current models for atmospheric transport and deposition of mercury greatly overestimate the actual, measured mercury deposition in critical areas directly downwind of power plants, such as Pennsylvania. Part of the reason for this inaccuracy may be a rapid chemical change from Hg²⁺ to Hg⁰ within the plume structure. Preliminary laboratory studies and field observations at ambient air monitoring sites suggest this conversion may be occurring, but direct evidence of within-plume mercury speciation changes is lacking. Additional research and

field measurements are needed to determine the chemical speciation of mercury into elemental and oxidized forms and the changes of gas/particle fractionation as the material is transported downwind of the plant.